Operational hydrological forecasting of African river basins

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Operational hydrological forecasting of African river basins

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Introduction

Many river basins in Africa are poorly gauged. Spatio-temporal coverage of in-situ hydrological monitoring networks on the continent has been decreasing over the past few decades. At the same time, African water managers face increasingly difficult challenges because water resources are scarce in many basins and, as a consequence of climate and land use changes, the probability distributions of hydrological variables have changed. Floods and droughts threaten the livelihoods of millions of people and cause significant economic damage and loss of lives. In this context, satellite-based remote sensing has the potential to complement in-situ hydrological monitoring and provide critical support to integrated water resources management. In 2001, the European Space Agency (ESA) launched the TIGER Initiative to enhance the capability of key African water authorities to take advantage of remote sensing data in water management. The TIGER-NET project [1] is a major component of ESA's TIGER initiative. TIGER-NET provides an open-source operational hydrological modeling and data assimilation capability for basin-scale water management.

Method

The operational hydrological modeling component of TIGER-NET uses the SWAT model for rainfall-runoff modeling. Calibration of SWAT models is performed using a shuffled complex evolution algorithm through the model-independent parameter estimation software PEST. Runoff outputs from SWAT are used to force a routing model of the river network. Flow routing is performed using the Muskingum approach. In operational forecasting mode, the state variables of the routing scheme are updated using a Kalman filter [2]. As input to the modeling system we use global land cover, soil type, and elevation datasets. Precipitation and reference evapotranspiration forecasts are provided by the NOAA Global Forecasting System (NOAA-GFS). In operational forecasting mode, the model can ingest both in-situ discharge data and altimetric measurements of water level. The entire modeling system (pre-processing of forcing data, rainfall-runoff model, routing model, calibration and data assimilation) is implemented in the open-source GIS environment Quantum GIS (QGIS) using the Python interface provided by the Sextante geoprocessing platform. The modeling system exclusively uses open-source software and data and can thus be deployed and used by any African water stakeholder irrespective of economic and financial constraints.

Results

The operational modeling system has been deployed for the Chari-Logone, Kavango and Mokolo river basins in the first phase of TIGER-NET. In the second phase of the project, water authorities from the Volta and the Zambezi basins have requested operational hydrological modeling capability. After bias correction of the NOAA-GFS precipitation forcing, the modeling system showed generally satisfactory to very good performance in all river basins with Nash-Sutcliffe model efficiencies (NSE) ranging from 0.5 to 0.9 at calibration and validation stations (see figure 1).

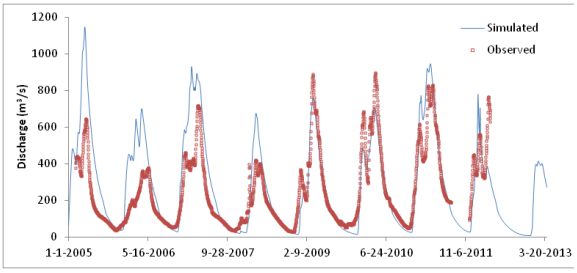

Figure 1 Simulated (blue) and observed (red) discharge in the Kavango River at Rundu

Performance of the operational forecasting system was evaluated for historical test periods for both Kavango and Mokolo. The Kavango operational forecasting system had good skill up to forecast horizons of 8 days. The 8-day ahead forecast showed an NSE of 0.87 and a root mean square error equal to 25% of the average discharge at Rundu. Forecasting for the Mokolo was less successful. This was mainly due to the small size of the catchment because model updates were washed out of the routing scheme already after a few days.

References

[1] http://tiger-net.org/

[2] Michailovsky, C.I., Milzow, C., Bauer-Gottwein, P. (2013): Assimilation of Radar Altimetry to a Routing Model of the Brahmaputra River. Water Resources Research, 49(8): 4807-4816